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Editorial: The role of perceptual manipulations of XR in neurological rehabilitation

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Editorial on the Research Topic
The role of perceptual manipulations of xr in neurological rehabilitation

Neurological rehabilitation aims to restore function and improve the quality of life for individuals with neurological impairments. In recent years, advancements in extended reality (XR) technologies, including virtual reality (VR), augmented reality (AR), and mixed reality (MR), have played a pivotal role in influencing and manipulating human perception. These technologies enhance neuroplasticity Cheung et al. (2014), promote motor learning Im et al. (2016), and alleviate symptoms like pain or neglect Dunn et al. (2017) by targeting specific sensory modalities such as visual, tactile, auditory, vestibular, and proprioceptive. As XR technological advances have improved, these allowed XR developers to manipulate perceptions of end-user experiences by creating real-world sensations in a virtual world. However, opportunities for object manipulation and body movement through virtual environments (VEs) provide frameworks that, in varying degrees, are perceived as comparable to similar opportunities in the real world.

Through manipulations in the XR, we can manipulate individual sources of sensory information, which are physiologically bound together. This makes it possible to study the contribution of these individual sensory inputs and multisensory integration to self-perception and motor control. This sensory manipulation takes advantage of the capabilities of XR to induce activation through observation and to perturb reality to target specific neural networks, particularly those neural networks associated with sensorimotor learning, thus promising the effective potential for rehabilitation training; e.g., to alleviate phantom limb pain Dunn et al. (2017) or improve upper limb function Regenbrecht et al. (2012). Treatment effects often arise when there's a discrepancy between misleading visual feedback and other sensory inputs, which can significantly influence the outcome Saunders and Knill (2004); Ramachandran and Altschuler (2009). However, it is important to understand the neural mechanism underlying these innovative rehabilitation strategies Merians et al. (2009); Georgiev et al. (2021); Hao et al. (2022). Little is understood about the susceptibility of brain function to various sensory manipulations within the VE. It is critical to determine the underlying neurological mechanisms of moving and interacting within a VE and to consider how they may be exploited to facilitate activation in neural networks associated with sensorimotor learning.

This Research Topic, *The Role of Perceptual Manipulations of XR in Neurological Rehabilitation*, collected scientific contributions regarding advances in XR technology for the further understanding and treatment of neurological disorders. Five articles have been included in this Research Topic (four original research articles and one review) examining perceptual manipulations within virtual spaces. The first article by Eckhoff et al. investigate how AR influences the perception of thermal pain and detection thresholds. Participants experienced their hands covered in virtual flames or blue fluid using an AR. Virtual flames induced analgesic and hyperalgesic effects, whereas blue fluid did not affect thermal thresholds. The study highlights AR's potential as a tool for pain modulation and therapy, altering sensory experiences through visual-auditory illusions. The second article by Winkler et al. investigates how social context affects reactivity to smoking cues using VR. The study involved smokers and non-smokers exposed to smoking cues and neutral stimuli in social or neutral VR contexts. The presence of a social context reduced cravings in smokers and increased the time taken to approach the cigarette, suggesting a modulatory effect. The findings underscore VR's potential in exposure therapy for smoking cessation by simulating social environments and enhancing understanding and treatment of addictive behaviors. The third article conducted by Porffy et al., explores the development and validation of VStore, a VR-based intervention with an intent to increase the ecological validity of cognitive assessments. Involving healthy adults and patients with psychosis, the study found high completion rates and no adverse effects. Performance metrics varied significantly across age groups and patients, indicating VStore's potential clinical utility for neuropsychological assessment, particularly in evaluating cognitive decline and functional capacity. The fourth article presented by Roy et al. evaluate the efficacy of Motion-Assisted, Multi-Modal Memory Desensitization and Reconsolidation (3MDR) for treating post-traumatic stress disorder (PTSD) in veterans with mild traumatic brain injury (mTBI); the results showing significant reductions in PTSD severity. The study suggests that 3MDR, potentially enhanced by the eye movement component, is effective for PTSD treatment in veterans with mTBI, warranting further investigation in larger trials. The final article on this Research Topic by Crowe et al. systematically reviews the literature on the use of virtual therapists in immersive VEs for motor rehabilitation. The study examines the roles and representations of therapists in VEs, the nature of therapist-patient interactions, the activities conducted, and the experiences of both patients and therapists. Interactions between therapists and patients typically involve visual, haptic, or one-way audio feedback. The review emphasizes the need for future research to explore the roles of virtual therapists in greater detail, focusing on reducing therapist manual input, enhancing personalization, and improving individualized patient feedback to support the therapeutic alliance in VR settings.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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